CIRCULAR 6174 SEPTEMBER, 1929

DEPARTMENT OF COMMERCE

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BY

WM. F. NETZEBAND

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METHOD AND COST OF MINING ZINC AND LEAD AT NO. 3 MINE, TRI-STATE DISTRICT, CRESTLINE, KAN.[1]

By Wm. F. Netzeband [2]

INTRODUCTION

This paper describing the mining practices at the No. 3 mine, Tri-State district is one of a series being prepared by the Bureau of Mines on mining practices, methods, and costs in the various mining districts of the United States.

LOCATION

The mine is located in an isolated camp about 1 1/2 miles east of the town of Crestline, Kan. Its relation to the main Picher, Okla., camp is shown in the accompanying map. (Fig. 1.)

HISTORY

The property was acquired by lease in February, 1924, after it had been drilled, a shaft sunk, and a mill built. The mine is situated in what was then practically virgin territory, and considerable water was encountered. Later on drilling proved up several isolated ore bodies and "field" shafts were sunk on them. Two "field" shafts were completed in 1925 and one in 1926.

The mill has a capacity of 400 tons in 10 hours and is equipped with a flotation unit.

GEOLOGY

The stratigraphy of this area is much the same as in the main Picher, Okla., camp; but the formations are all shallower.

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[1] - The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Circular 6174 ."

[2] - One of the consulting engineers, U. S. Bureau of Mines.

The normal Cherokee shale ranges from 30 to 40 feet in thickness with occasional pockets where it attains a thickness of 90 to 100 feet. The Short Creek oolite is found at 140 feet and the Grand Falls chert at 240 feet. The Grand Falls chert is about 20 feet thick and mineralized, but the ore is not rich enough to be of commercial grade at present.

ORE DEPOSITS

The ore deposits are closely associated with the shale pockets and are somewhat similar to the ore deposits of the old Joplin, Mo., camp. The ore body at the mill shaft apparently entirely surrounds the shale pocket with which it is associated. This relationship is shown in the plan, Figure 2, and in the section, Figure 3. The other ore bodies lie along only one side of shale pockets.

The ore occurs in bowlder ground for about 50 feet below the Short Creek oolite horizon, that is, at a depth of 140 to 190 feet. There are isolated pockets of lead ore above the oolite horizon, but they have not been large enough to mine.

The ore is sphalerite and galena associated with jasperoid, blue, gray, and white flint, gray dolomite, pink crystalline dolomite, and calcite. The ore occurs disseminated in the jasperiod and flint or cementing bowlders of the same material. The crystalline dolomite and calcite also occur, cementing the bowlders of jasperoid and flint.

The ore bodies are narrow but thick, and they are controlled by the shale pockets with which they are associated. Very few pillars are necessary, because the character of the ground will not allow drifts over 20 feet wide, and in most cases this is the width of mineable ore.

EXPLORATION AND ESTIMATION OF ORE RESERVES

After the character of the ore bodies was determined by the early drilling it was found that this property was adaptable to what is locally known as "shale drilling". By this method of drilling the contact between the Cherokee shale and the Boone formation is determined by a series of holes which are drilled through the shale but only about 10 feet into the underlying Boone formation. The holes are drilled at regular intervals, usually on 200 or 400 foot centers. From the data obtained, the base of the shale is contoured and deep drilling concentrated around the edges of the deep shale pockets. By this method considerable territory can be eliminated as unfavorable at small cost.

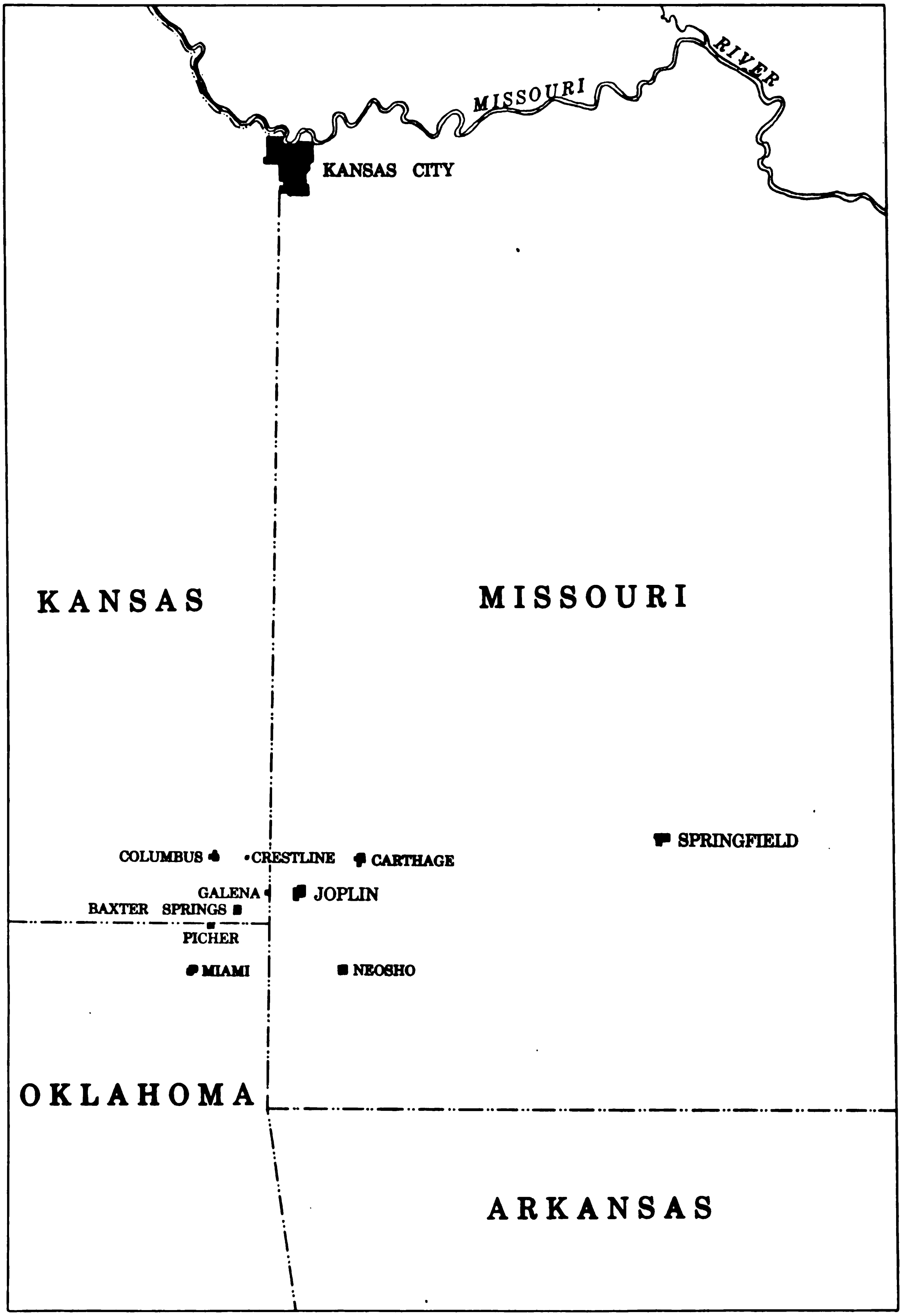

Figure 1. – Map of district showing relation of Crestline, Kan. to the main Picher, Okla., camp

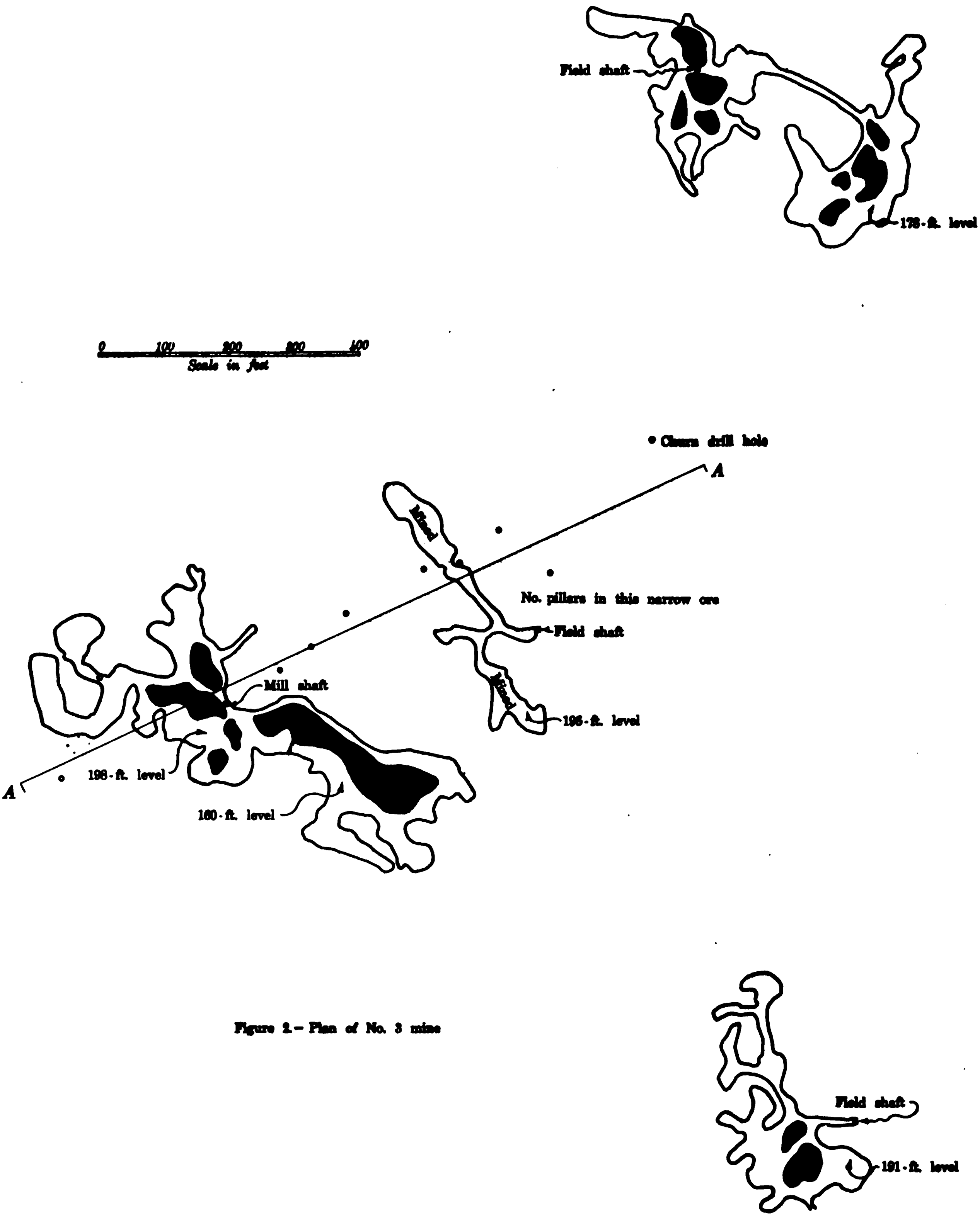

Figure 2.- Plan of No. 3 mine

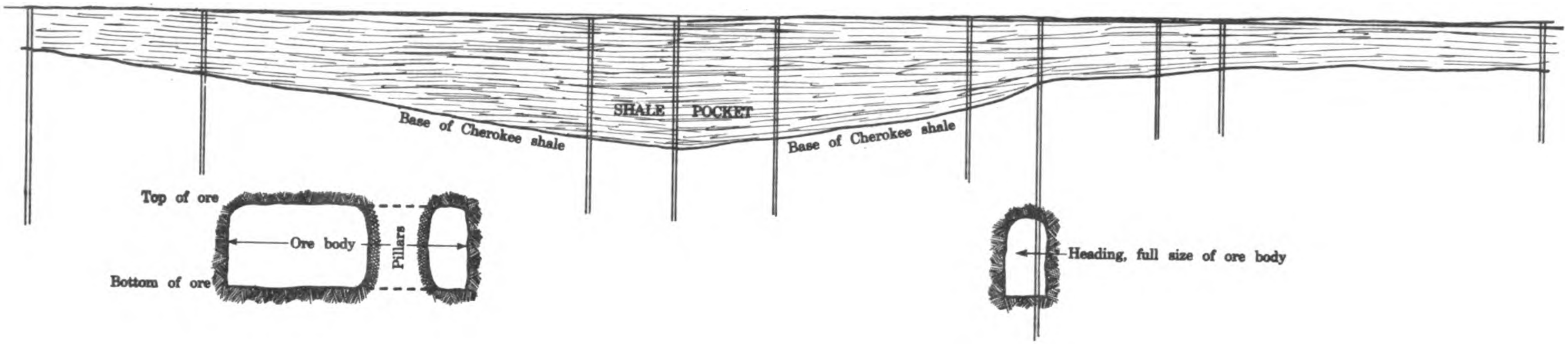

Figure 2. – Cross section *A–A*, showing relation of shale pocket to ore body

The shale holes are drilled for 40 to 60 cents per foot, depending upon the length of move and the topography of the tract being drilled. Deep holes are drilled for $1.10 to $1.50 per foot. Much of the drilling on this property cost $1.50 per foot because of the bowldery character of the ground. It is difficult ground to drill, as is witnessed by the number of strings of tools which were lost and never recovered. Wherever a hole could be finished with the 6¼-inch string of tools the price was $1.10 per foot.

There has been 37,246 feet of drilling on this property.

EARLY MINING METHODS

The methods of mining have not changed at this mine; the ore is still loaded by hand into cans; the cans are trammed by hand to the shaft and then hoisted to the surface, dumped into the hopper without being detached from the rope, and returned immediately to the shaft bottom.

The mining method, the open-stope system with pillar support, has remained the same, but the character of the ground requires the use of fewer pillars than at most mines of the district.

DEVELOPMENT SYSTEM

The first shaft was sunk by the original company to a depth of 160 feet. To permit sinking the shaft to reach this depth a 27-inch churn-drill hole was put down near the shaft and a 10-inch vertical centrifugal pump (Texas pump) installed to lower the water. This shaft was made the mill shaft.

Main Shaft. - The mill shaft was sunk by the original company to a depth of 160 feet but was later deepened to 205 feet by the present company. Considerable water was encountered, as this mine was in practically virgin territory; this hindered the sinking of the shaft to the bottom of the ore.

Part of the ore body was mined at 160 feet and then stoped successively to 190 and 205 feet as the water was lowered and the shaft deepened.

Auxiliary Shafts. - Three "field shafts" have been sunk on isolated ore bodies and these were connected with the mill by surface trams. The shafts were sunk on contract with the contractor furnishing the labor and the company all supplies and equipment.

One of the shafts was finished on company time because of pockets of gas in the open, bowldery ground which gave considerable trouble. This gas was principally carbon dioxide, and some difficulty was experienced in removing it with the small suction fans available.

No costs are available for either of these shafts.

"Pull" Drifts. - Prospect or "pull" drifts are driven 7 by 7 feet in cross section. All such drifts have been driven on company time, and no costs are available. Unless a drift must be finished promptly it is usually drilled whenever a machine is available from the regular mining operations.

A 12-hole round using the 4-hole diamond cut, with two side holes, three roof holes, and three "stope" or bottom holes, is used. The holes are drilled approximately 7 feet deep, and 6 feet is broken per round. The cut holes are loaded with 8 to 10 sticks of 30 per cent gelatin powder and the other holes with about 7 sticks of the same strength powder. The sketch Figure 4 shows the arrangement of the holes.

Raises. - It has not been necessary to drive any raises at this time.

PRESENT MINING METHOD

The plan and section of Mine No. 3 are shown in Figures 2 and 3. The method used at this mine is different from that generally used throughout the district. No heading is driven ahead of the main stope and much of the time no drilling is necessary; a crevice or opening between bowlders is often conveniently placed and can be loaded instead of drilling a hole.

The ground is of such loose character that it is only necessary to blast the bottom to maintain the floor grade, and the rest can be trimmed down with roof bars.

The ore breaks into large bowlders, making it necessary to do a considerable amount of "bowlder popping" before loading into cans. As a matter of fact, more drilling is done to break the bowlders than is necessary in breaking the rock at the face. All bowlders are drilled with jackhammers before blasting.

All blasting is done with 20 per cent gelatin powder. This powder costs $0.1225 per pound.

Underground Support. - The ore bodies are so narrow for the most part that no pillars are necessary, but some of the ground becomes so loose that timbers are required. Caps and posts of round timbers are set on 6-foot centers and lagged above and if necessary on the sides. The floor is hard so no mud sills are required.

The ground is so loose and bowldery that extreme care must be taken to keep the roof well trimmed. As mentioned earlier, only the lower stope is blasted, and the rest of the ore is broken down with roof bars. Because extreme care is imperative this mine has had an excellent record for no time lost from accidents, especially from falling rock.

DRILLING AND BLASTING PRACTICE

Compressors. - Air is furnished by a belt-driven, 2-stage compressor with a capacity of 1,200 cubic feet per minute. At present air is being used for the drill sharpner, 13 machines in the mine and two 2-inch pumps.

Drills. - Several makes of drills are used but they are all of the heavy Leyner type except that jackhammers are used for block-holing. Each is operated by two men. The drills are mounted on posts for "pull" drift work and on tripods for drilling the stopes. All Leyner drills use 1¼-inch hollow round steel and the jackhammers use 1-inch hexagon hollow steel.

The standard cross bit with an 18-degree taper is used. The gauges are dropped one-fourth inch for steel changes of 2 feet. The starter bits are 2¾ inches in diameter and the holes are finished 1¾ inches in diameter. The gauge of the jackhammer steels is 2 3/8 inches.

The blacksmith shop is located on the surface near the mill shaft and is equipped with a power sharpner and necessary equipment for ordinary repair work around the mine and mill.

Blasting. - The blasting practice at Mine No. 3 is unique in that no heading round is necessary and very often no drilling is required to break the ore at the face. The arrangement of the holes for the stope round is shown in Figure 5.

Three holes are required to break the stope, and in a drift 20 feet wide, which is the average for the mine, the holes are drilled 14 feet deep. A hole is drilled in each corner of the drift looking slightly out and down. The hole is drilled downward with a pitch of 1 inch to the foot, and the collar is so placed that the bottom of the hole will be below the grade of the drift. A third hole is placed in the center of the drift and is drilled downward with the same pitch as the corner holes.

Very often a crevice is conveniently placed, and a hole can be "spudded in" with a bar made of 1-inch hexagon steel sharpened at one end. When holes are "spudded in" the depth is reduced to about 10 feet.

No splitter holes are drilled in this mine, only the three stope holes.

The holes are squibbed twice before the final charge is loaded. The first time the hole is squibbed with two to six sticks of powder and 24 hours later they are squibbed with five sticks of powder. The center hole is shot with 20 sticks to 3 boxes of powder, depending on the size of the chamber and the load to be broken. The corner holes are shot with about one-half this amount of powder.

The powder is all 20 per cent gelatin dynamite. The primers are made by inserting a No. 6 cap in the center of the stick of powder and placing this in a safety tube. The type of tube used is shown in Figure 6. This tube protects the fuse from abrasion by sharp projections in the hole, which is very ragged in this type of ground.

The blasting breaks between 10 and 20 feet of ore depending upon the depth of hole and character of the ground; the rest is trimmed down with roof bars. The roof trimmer works first from the pile of broken ore and trims down as much as he can conveniently reach without exposing himself to falling rock. When the roof trimmer has trimmed all that he can reach from the broken ore he uses ladders for the remainder of the ore. The ladders come in 20-foot sections and it is very often necessary to use three sections for the drifts are cut from 40 to 60 feet in height. The drifts are all so narrow that the roof trimmer can work on ladders placed against the walls of the drift, so that he is fairly well protected from bowlders rolling down the stope or unexpectedly large masses of broken rock coming down from the roof.

The ore is broken down as large bowlders and must be blasted before loading into cans. All bowlders are drilled with jackhammers before shooting.

The average tonnage per machine shift is 60 to 65 tons.

LOADING AND TRAMMING

All loading is by hand shoveling into cans set on low trucks. The cans are 32 inches in diameter by 32 inches deep, and have a capacity of 0.6 tons of ore. The track gauge is 17 inches.

No mules are used under ground; the hauls are all so short that all tramming is done by hand. Seven men are employed as trammers at three of the shafts, and at the fourth shaft each shoveler is given a "bruno hand" who keeps the ore mucked down onto the boards and helps the shoveler tram the loaded can to the shaft where he hooks his own cans. No "tub hookers" or "bumpers" are employed at this shaft because of the small tonnage which comes from it. The "bruno hand" is paid shift wages.

The ore at the "field" shafts is drawn from the hoppers into wooden cars and trammed to the mill by a gasoline locomotive. The cars are then pulled up an incline by a geared electric hoist and dumped into the mill hopper. One locomotive handles the ore from the three "field" shafts.

PUMPING

The burden of keeping the district unwatered has been taken by one of the other mines, and all mines in the district share the expense.

To take care of the surface water two 2-inch steam pumps operated by compressed air and a triplex pump driven by a 5-horsepower motor are in use. These pumps have a combined capacity of about 30 gallons per minute. Ordinarily they are run for a short time each morning, but during the wet season it is often necessary to run them 10 hours each day.

Record of labor performed at Mine No. 3 for 1927

	Total shifts	Tons per shift
Trammers	2,312	57.25
Drill runners and helpers	4,624	28.62
Muckers	4,335	30.53
Miscellaneous labor	2,601	50.89
Total underground operations	13,872	9.54

Ore hoisted during 1927 amounted to 132,384 tons.

PERCENTAGE OF EXTRACTION

The percentage of extraction will vary considerably at the several shafts of the property. At the mill shaft about 6 per cent of the area mined is left in pillars, whereas in the "field" shafts this figure varies from zero to 22 per cent. It is doubtful if many of the pillars can be or are rich enough to be recovered so that the extraction at the several shafts will range from 78 to 100 per cent.

WAGES AND CONTRACT SYSTEM

All labor except mucking is based on an 8-hour day. Muckers are paid on contract, 10.5 cents per can of 0.6 tons. Muckers at one shaft are allowed a "bruno helper" who keeps the ore mucked onto the boards and helps tram the can to the shaft. The "bruno helper" is paid shift wages.

An experienced mucker will load 40 or more cans in an 8-hour shift. Many will average 80 or more cans per shift if they are given a good working place where the ore will run down onto the boards.

The following wage scale was in effect during 1928 when zinc ore prices stayed at $40.00 or under for prime western ore.

Machine men	$ 4.25 [1]	
Machine helpers	3.75	
Blacksmith	5.00	
Screen men	3.50	
Bruno helpers	3.50	
Trammers	3.50	
Mucker boss	4.50	
Ground foreman	50.00	per week
Roof trimmer	4.25	
Track men	4.25	
Locomotive runner	5.00	
Brakeman	3.50	
Hoistman	4.75	
Tub hooker	4.75	
Compressor man	40.00	per week

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[1] - Unless otherwise mentioned the wage is per shift.

The locomotive runner also operates the hoist on the incline tram and the brakeman loads the cars from the hopper at the field shaft and hooks the cars at the incline tram.

The above wage scale is based on $40.00 zinc ore. If the price goes to $45.00 and stays there for one week all wages are automatically raised 25 cents per shift, and muckers are raised one-half cent per can. In the same manner, for every $5.00 increase in the price of zinc ore above $45.00 the wages are raised at the same rate, but for every drop of $5.00 the wages are reduced. Wages are not reduced when the ore price drops below $40.00, for this is the base price for the wage scale. A week is always allowed between the wage changes to make sure that the market will not fluctuate above or below the critical price.

VENTILATION

The open, bowldery ground in which the ore is found contains considerable quantities of marcasite and occasional pockets of gas, the major portion of which is carbon dioxide. The oxidation of the marcasite makes the ground very hot, and the pockets of gas are frequent enough to be a source of danger if artificial ventilation were not resorted to.

During 1927 there were four blowers direct-connected to 2-horsepower motors placed over churn-drill holes. These were enough to aid the natural ventilation at the shaft and maintained the air at the working face in good condition, both as to purity and temperature. None of the working faces are far enough from the shaft bottom to require elaborate ventilating equipment.

MINING COSTS

Below is the total cost of delivering a ton of ore into the mill hopper at Mine No. 3.

Cost of delivering 1 ton of ore into the mill hopper

	Mining	General underground	Surface Expense	Total
Labor	$ 0.4256	$ 0.0926	$ 0.1297	$ 0.6479
Supervision	.0271			.0271
Compressed air, drills, etc.	.0756			.0756
Power cost		.0473	.0549	.1022
Explosives	.1169			.1169
Other supplies		.0223	.0095	.0318
Total	$ .6452	$ .1622	$ .1941	$ 1.0015

No powder men are employed at this mine; the machine men load and fire their own holes.

The surface expense, which is directly applicable to underground operations, includes the hoist and screen room and the surface tram from the field shafts to the mill hopper. This expense is high as compared with the mines in the Picher camp because ore was being hoisted at three "field" shafts besides the mill shaft.

SUMMARY OF COSTS
IN UNITS OF LABOR, POWER, AND SUPPLIES

Mine No. 3, Tri-State District

Tons ore mined and hoisted - 132,384.
Period covered - year 1927.

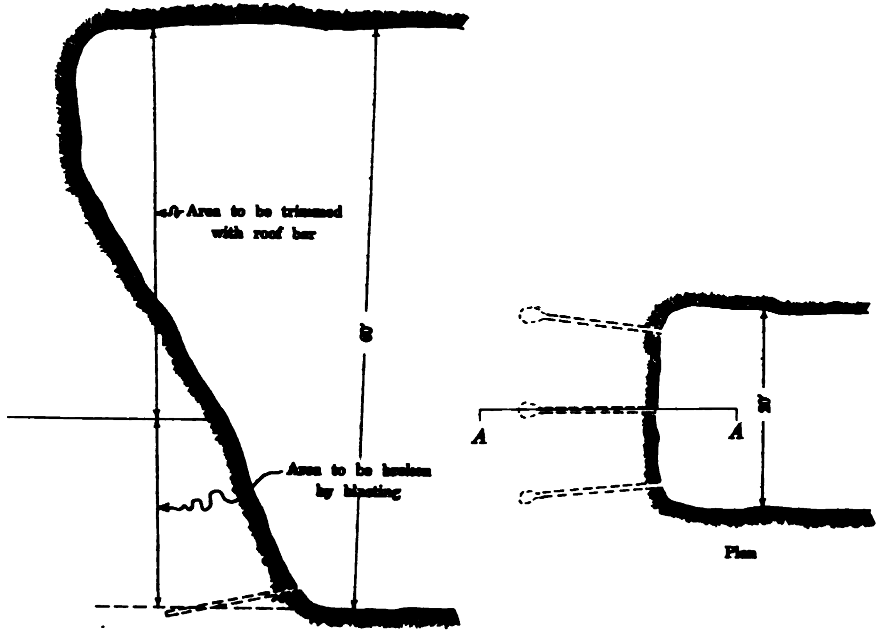
	Man hours per ton	Per cent of total underground labor
A. Labor		
Breaking (drilling and blasting)	0.139	16.63
Mucking	.262	31.34
Haulage and Hoisting	.366	43.78
Supervision	.069	8.25
Total Underground Labor	.836	100.00
General and Surface Labor	.069	
Total Labor, Surface and Underground	.905	

Tons per man, total underground	9.54
Tons per man, total underground and surface	9.19
Labor, percentage of total cost	64.69

B. Power and supplies.

Power.	kw. h. per ton
1. Air compression	1.40
2. Hoisting	2.77
Total power	4.17

Explosives - 20 per cent gelatine, 0.875 pound per ton.
Other supplies in percentage of total power and supplies - 9.74.
Supplies and power, percentage of total cost - 35.31.


Area to be trimmed with roof bar
Area to be broken by blasting
A
A

Section A-A

Plan

Figure 5. – Stope round

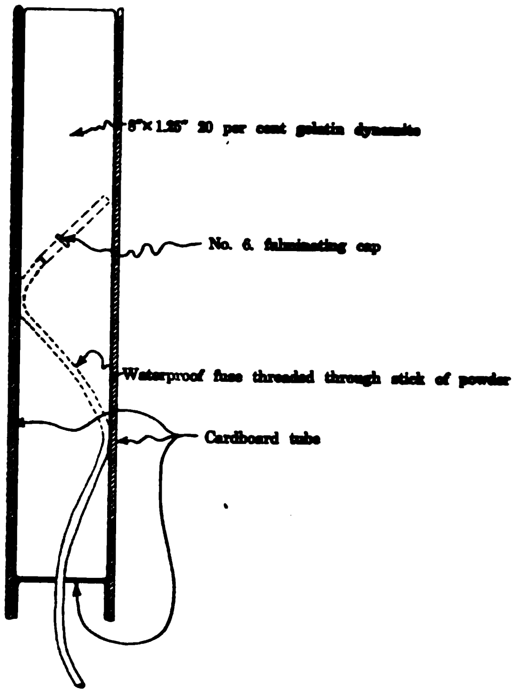

8"×1.25" 20 per cent gelatin dynamite
No. 6 fulminating cap
Waterproof fuse threaded through stick of powder
Cardboard tube

Figure 6. – Method of inserting primer in safety tube

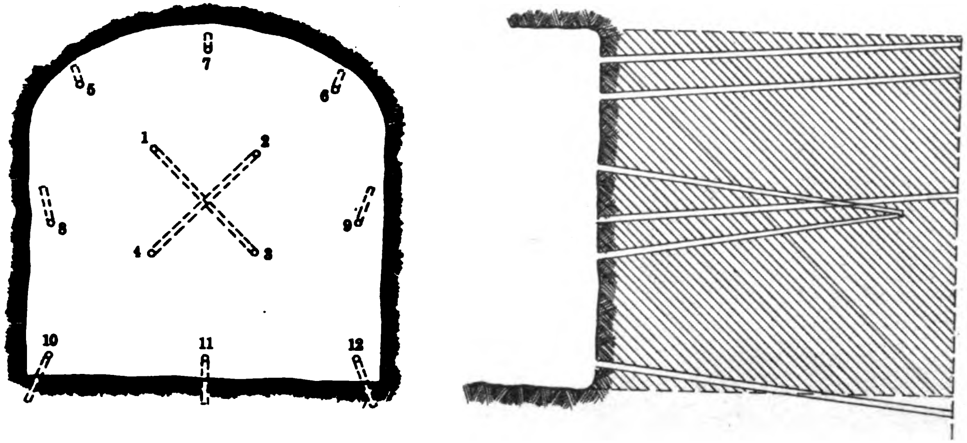


Figure 4. – Plan and section of pull drift round